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Airlaid method with an improved through-put rate

Description

The present invention relates to a method for producing a fibrous nonwoven by applying an aerodynamic process (hereinafter referred to as "airlaid process"), a fibrous nonwoven produced according to this method as well as a short fiber suitable for use in said method.

It is known in the art to form fibrous nonwovens by applying airlaid processes. These processes are dry processes wherein the fibers, after having been subjected to opening, are transferred to an air stream and subsequently airlaid on a screen surface.

So far, primarily cellulose fibers have been used in airlaid processes, which cellulose fibers may have minor amounts of other fibers admixed thereto, such as viscose fibers. One problem associated particularly with the use of major amounts of viscose fibers resides in that the throughput or capacity achievable in conventional airlaid machinery is substantially lower than when use is made of cellulose fibers only. By throughput it is meant the weight of fibers transferred to the conveying air stream within a specific period of time. Moreover, considerable deviations in the target basis weight are encountered and thus the quality of the resulting fibrous nonwovens is poor.

The applicants of the present application have conducted tests and found that, when use is made solely of commercial

quality short viscose fibers in an airlaid process, merely a throughput is achieved which usually accounts for less than 10% of the throughput achievable with cellulose fibers.

There is thus a need for airlaid processes which enable an increased throughput with a higher amount of viscose fibers and thus allow to make use of the capacity of the production machinery more efficiently.

The applicants of the present invention have surprisingly found that, by providing short viscose fibers with a finish, the throughput in an airlaid process can be considerably increased. The improvement achieved is in a magnitude which even exceeds the throughput obtainable with the conventional use of cellulose fibers so that it is believed that the process according to the invention is generally applicable independent of the specific fiber used.

It is principally known in the art to provide fibers with a finish. Fibers which have been provided with a finish are used, for example, in carding processes. However, this is a process which is principally different and, moreover, uses longer fibers. According to the applicants' todays' knowledge, there has so far been no reason to use fibers with a finish in airlaid processes.

The invention will be described in detail hereinafter with reference to the attached drawings, wherein:

Figure 1 is a graph illustrating the dependency of the throughput on the moisture content, and

Figure 2 is a graph illustrating the dependency of the throughput on the amount of finish.

The present invention thus relates to a method for making a fibrous nonwoven, said method comprising the steps of depositing at least one short fiber-including layer by an airlaid process, wherein at least a fraction of the short fibers is provided with a finish in an amount of more than 0.035 percent by weight, based on the fiber weight of the short fibers provided with said finish.

As used herein, a fibrous nonwoven is understood to be a layer of fibers comprising short fibers in random array. Short fibers are defined herein to mean fibers having a length in the range of from 2 to 12 mm. The term short fibers, as used herein, includes all short fibers used in the process, exclusive short binder fibers and superabsorbent fibers which might be present. A "short fiber-including layer", as used herein, means a layer wherein the fibers which primarily constitute said layer are short fibers, but additional materials such as binder materials, superabsorbents etc. may be present in the form of longer fibers or in a form other than fibers. If binder materials and/or superabsorbents are present and are not present in the form of short fibers, the short fibers generally account for more than 50 percent by weight, typically more than 60 percent by weight, of the layer. Short fibers plus short binder fibers and/or short suberabsorbent fibers generally account for more than 90 percent by weight, typically more than 95 percent by weight, of the layer.

According to the invention, at least a fraction of the short fibers is provided with the finish. Generally, at least 5 percent by weight of the short fibers are provided

with the finish, preferably at least 10 percent by weight such as at least 25 percent by weight, for example, at least 50 percent by weight. An example for the use of fiber blends is a blend wherein, e.g., preferably more than 25%, particularly more than 50%, for example, the total of the short fibers involving problems as far as the throughput is concerned, such as viscose fibers, are provided with the finish, while the short fibers which are unproblematic to use comprise no finish. Alternatively, substantially all short fibers used in the airlaid process can be provided with the finish.

According to a special embodiment of the method according to the invention, a binder material may be airlaid in addition to the short fibers. As used herein, binder material is generally understood to be materials which, due to their dissolving or melting capacity, are suitable to bind short fibers. The binders may be present in arbitrary form, e.g., as powder etc., to the extent that they are suitable for use in an airlaid process. However, binder materials are preferably also used likewise in the form of short fibers, i.e., short binder fibers.

Examples of fibers which, due to their dissolving capacity, are suitable for use as binder fibers are polyvinyl alcohol fibers (PVA fibers) and alginate fibers. Fibers which, due to their melting capacity, are suitable for use as binder fibers generally comprise melt adhesives or fibers including thermoplastic material having a lower melting point than the fibers to be bound. Melt binder fibers may be used as full-profile fibers or multi-component fibers. A preferred melt binder fiber is a two-component fiber (BICO fiber), for example, a bi-component fiber comprising a fiber sheath made of a polymer having a lower melting point than the polymer of the fiber core. One example for such a

fiber is a two-component fiber comprising a polyester core and a polyethylene sheath.

The term "short binder fiber", as used herein, relates to fibers having a length in the range of from 2 to 12 mm, preferably 4 to 8 mm. Generally, the short binder fibers have a length-to-weight ratio of 1.0 to 6.0 dtex, preferably 2.0 to 4.0 dtex such as 3.0 dtex.

The binder is used in an amount which is eventually determined by the desired properties of the final product. Therefore, the parameters which influence the amount of binder used are the type of binder and the type of fibers or fiber blend to be bound as well as the strength, softness/stiffness and basis weight etc. of the final product. Generally, the amount of binder used is 1 to 30 percent by weight, based on the total weight of the short fibers to be bound and the binder, particularly 1 to 20 percent by weight such as 3 to 10 percent by weight, for example, 5 to 8 percent by weight.

The inventors have also found that the moisture content of the short fibers used in the airlaid process has an influence on the throughput. Accordingly, the short fibers used preferably have a moisture content in the range of from 4 to 16%, particularly of from 6 to 14% such as 8 to 12 %. The moisture is measured according to the method described hereinbelow.

Short fibers which are suitable for use in the process according to the invention comprise substantially all fiber types known in the art, i.e., natural fibers, cellulosic man-made fibers, synthetic fibers and inorganic fibers as well as combinations thereof. Examples of natural fibers are natural vegetable fibers such as cellulose, cotton,

jute, flax, hemp and coconut fibers as well as natural animal fibers such as wool or silk. Cellulosic man-made fibers comprise regenerated cellulose fibers such as viscose fibers, cuprous fibers and Lyocell fibers. Synthetic fibers comprise, for example, polyolefin fibers, polyester fibers and polyamide fibers. Inorganic fibers comprise glass fibers, silicate fibers, carbon fibers, boron fibers and metal fibers.

Preferred for use in the method according to the invention are natural fibers, particularly natural vegetable fibers and cellulosic man-made fibers, in particular cellulose fibers, cotton fibers, viscose fibers and Lyocell fibers.

As mentioned above, the method according to the present invention was originally developed for use of a high amount of viscose fibers. According to a preferred embodiment of the invention, the short fibers thus comprise short viscose fibers, at least a fraction of the short viscose fibers being provided with the finish. Preferably, at least 20%, even more preferably at least 50%, of the short viscose fibers are provided with the finish. For example, all of the short viscose fibers are provided with the finish.

It is advantageous for the short viscose fibers to have a multi-limbed cross-section, for example, a three-limbed cross-section. Such fibers are known in the art, for example, from US patent no. 5,643,914, the disclosure of which is incorporated herein by reference. Fibers having a three-limbed cross-section are, for example, shown in Figures 1 to 5 of said document.

According to this embodiment, the viscose fibers are used in an amount of more than 85 percent by weight, based on the total weight of the short fibers, particularly in an

amount of more than 90 percent by weight such as more than 95 percent by weight. For example, exclusively short viscose fibers, i.e., 100 percent by weight, are used as the short fibers.

As defined herein, short fibers have a length in the range of from 2 to 12 mm, preferably a length in the range of from 4 to 8 mm such as 5 to 6 mm. Generally, the short fibers have a length-to-weight ratio of 1.0 to 6.0 dtex, preferably 2.0 to 4.0 dtex, for example, about 3.3 dtex.

In the process according to the invention a superabsorbent material may be used in addition. Superabsorbents (SAP) are well known in the art and are thus not described herein in further detail. SAPs usually consist of acrylate-based polymers and are characterized in that they are capable of absorbing many times their own weight of aqueous fluid. The superabsorbent materials are used in the process according to the invention in any suitable form which is compatible with the airlaid process, such as in the form of granules, preferably in the form of fibers, particularly short fibers having a length in the range of from 2 to 12 mm, particularly 4 to 8 mm. If use is made of superabsorbent materials, the amount used is usually 0.1 to 50 percent by weight, particularly 5 to 10 percent by weight, based on the weight of the short fibers (exclusive the amount of short binder fiber which might be present).

The finish is present in an amount of more than 0.035 percent by weight, based on the weight of the short fibers provided with the finish. The finish amount, as used herein, is understood to constitute the amount of finish as indicated by the fiber manufacturer to be actually present on the fiber.

The amounts indicated in this description thus relate to analysis values of the fiber manufacturer (Acordis), as determined by Soxleth extraction, derivatization (methylation) of the sample, gas-chromatographic separation and detection by means of flame-ionization detector.

The amount of finish, based on the viscose fibers, is preferably more than 0.05 percent by weight, more preferably 0.10 percent by weight, and most preferably more than 0.15 percent by weight. The upper limit of the finish amount is the amount at which a further increase of the throughput does not appear to make any sense anymore, for example, due to other limiting process parameters, at which the throughput is nearly optimal and further costs for more finish do not appear to be justified or at which the high finish content results into or contributes to undesired product properties. The maximum finish amount is thus governed by the airlaid machinery used, the short fibers or short fiber blends used as well as by the final product and its desired properties.

As far as viscose fibers are concerned, it is presently contemplated that the maximum finish amount is 1 percent by weight, particularly 0.75 percent by weight such as 0.50 percent by weight, based on the weight of the short fibers provided with the finish. For other fiber types analogous finish amounts are contemplated.

Suitable as finish is any material which, when being present on the surface of the short fibers in the indicated amount, is suitable to improve the throughput of the airlaid process according to the invention. Preferably, the finish is selected from:

(a) ester derivatives and ether derivatives of polyethylene oxide and polypropylene oxide of the general formula:

$$R1-(CO)_o-O-[-CH_2-(CH_2)_m-O-]_n-(CO)_p-R1$$

wherein R1 is, in each case independently of each other, a saturated or unsaturated hydrocarbon moiety having 12 to 22 carbon atoms, particularly 14 to 20 carbon atoms, which moiety may contain one or more free hydroxyl groups, o and p are independently of each other 0 or 1, m is 0 or 1, and n is 1 to 15, preferably 3 to 11, particularly 4 to 7,

(b) mono-, di- and triesters of sorbitanes with fatty acids of the formula R1-COOH, wherein R1 is, in each case independently of each other, as defined above,

(c) mono-, di-, and triglycerides of fatty acids of the formula R1-COOH, wherein R1 is, in each case independently of each other, as defined above,

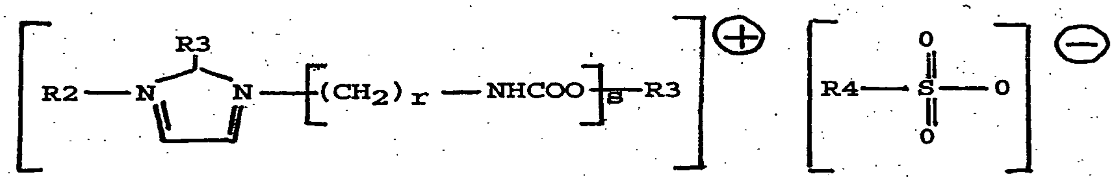
(d) imidazolinium ethosulfates and methosulfates

(e) ethoxylated and propoxylated derivatives of the compounds according to (a), (b), (c) and (d), and

(f) mixtures of compounds according to (a), (b), (c), (d) or/and (e).

The imidazolinium ethosulfates and methosulfates have generally a structure according to the following general formula (I)

(I)



wherein R2 is H or a C1-C6 alkyl moiety, R3 is, in each case independently of each other, a saturated or unsaturated hydrocarbon moiety having 6 to 22 carbon atoms, which moiety may contain one or more free hydroxyl groups, R4 is methyl or ethyl, r is 2, 3 or 4, and s is 0 or 1.

According to a first embodiment, preferred imidazolinium derivatives according to formula (I) are imidazolinium methosulfates (R4 = methyl), wherein R2 is methyl or ethyl, more preferably methyl, R3 is, in each case independently of each other, a hydrocarbon moiety having 14 to 18 carbon atoms, r is 2, and s is 1. According to a second preferred embodiment, R2 and R3 are defined as in the first preferred embodiment, and s is 0. According to a further preferred embodiment, R2 is methyl or ethyl, preferably methyl, R3 is, in each case independently of each other, a hydrocarbon moiety having 6 to 12 carbon atoms, r is 2, and s is 1. According to a still further preferred embodiment, R3 is an alkyl moiety.

Examples of ethylene oxide derivatives are the diesters of lauric acid, palmitic acid, oleic acid and/or stearic acid with polyethylene glycol having an average molecular weight of, for example, 400 or 600. Examples of sorbitan ester are the ethoxylated derivatives of sorbitan monoesters, diesters and triesters with lauric acid, palmitic acid, oleic acid and/or stearic acid. An example of glyceride derivatives is hydrogenated ethoxylated castor oil, and

examples of the imidazolinium derivatives are Rewoquat®W75 and Rewoquat®W90 of Degussa.

By use of short fibers, at least a fraction of which is provided with a finish, the throughput is preferably improved by at least 20%, more preferably by at least 50% and most preferably by at least 100%, as compared to the same short fibers, but without said finish.

The method according to the invention may be combined with further steps for forming a fibrous layer, particularly a fibrous nonwoven. Accordingly, the process according to the invention can be performed in that the layer which is formed is deposited on a previously formed fibrous sheet. The previously formed fibrous sheet may be, for example, a sheet formed by applying an airlaid process, or a sheet formed by applying another process, for example, a spunbond or meltblown sheet, or a combination of such sheets.

Moreover, the method according to the invention may comprise the laying of several layers, for example, the laying of two or three layers, if desired, in combination with one or more other sheets, as explained above. On the (top) layer according to the invention there may be deposited one or more other sheets, as explained above.

After the fibrous nonwoven has been formed in accordance with the invention, said fibrous nonwoven may be subjected to further process steps. Such steps comprise, for example, a heat treatment, particularly if thermoplastic binder fibers are used. In this case, the heat treatment comprises heating the fibrous nonwoven to a temperature above the softening point of the binder fiber or of the component of the binder fiber having the lowest melting point over a period of time which is sufficient to cause the fiber or

component to at least partially melt. Further optional process steps comprise compacting, embossing, printing etc.

The present invention also relates to a fibrous nonwoven produced according to the method of the present invention. Accordingly, the present invention also provides a fibrous nonwoven, comprising at least one short fiber-including layer, wherein at least a fraction of the short fibers is provided with a finish in an amount of more than 0.035 percent by weight, based on the fiber weight of the short fibers provided with said finish.

According to a special embodiment, the layer comprises short fibers in an amount of 70 to 99 percent by weight and binder material in an amount of 1 to 30 percent by weight, based on the total weight of short fibers and binder material.

The binder material is a binder material as described above in respect of the method according to the invention and preferably comprises short binder fibers, particularly multi-component fibers such as bi-component fibers including a polyester core and a polyethylene sheath. Generally, short binder fibers have a length-to-weight ratio of 1.0 to 6.0 dtex, preferably 2.0 to 4.0 dtex.

The short fibers are short fibers as described above in respect of the method according to the invention and preferably comprise natural fibers, particularly natural vegetable fibers and cellulosic man-made fibers, particularly cellulose fibers, cotton fibers, viscose fibers and Lyocell fibers.

According to a particular embodiment, the layer of the fibrous nonwoven according to the invention comprises short

viscose fibers, at least a fraction of which is provided with a finish. Preferably, at least 20%, more preferably at least 50%, of the short viscose fibers are provided with the finish. For example, all of the short viscose fibers are provided with the finish. Preferably, the short viscose fibers have a multi-limbed cross-section such as a three-limbed cross-section.

According to this embodiment, the viscose fibers are present in an amount of more than 85 percent by weight, based on the total weight of the short fibers, particularly in an amount of more than 90 percent by weight such as more than 95 percent by weight. For example, exclusively short viscose fibers are present as the short fibers.

As defined herein, the short fibers have a length in the range of from 2 to 12 mm and preferably a length in the range of from 4 to 8 mm such as 5 to 6 mm. Generally, the short fibers have a length-to-weight ratio of 1.0 to 6.0 dtex, preferably 2.0 to 4.0 dtex such as about 3.3 dtex.

The layer may comprise a superabsorbent material (SAP), preferably in the form of fibers, particularly short fibers, having a length in the range of from 2 to 12 mm, particularly 4 to 8 mm. If use is made of a superabsorbent material, the amount used is usually 0.1 to 50 percent by weight, particularly 5 to 10 percent by weight, based on the weight of the short fibers.

As described above in respect of the method according to the invention, the finish is present in an amount of more than 0.035 percent by weight, preferably in an amount of more than 0.05 percent by weight, more preferably in an amount of more than 0.10 percent by weight and most preferably in an amount of more than 0.15 percent by

weight, the maximum amount being 1 percent by weight, particularly 0.75 percent by weight such as 0.50 percent by weight. The indicated amounts relate to the weight of the short fibers provided with the finish.

The finish is a finish as described above in connection with the method according to the invention.

The fibrous nonwoven according to the invention may also comprise several layers according to the invention and/or other sheets, as explained above.

Generally, the short fiber-including layer of the fibrous nonwoven has a basis weight of 50 to 350 g/m², typically 75 to 250 g/m², particularly 150 to 220 g/m², such as about 180 g/m².

The density of the layer is generally 0.02 to 0.5 g/cm³, typically 0.03 to 0.2 g/cm³, particularly 0.04 to 0.1 g/cm³. The above values relate to the material web as deposited in the airlaid process before compacting process steps, such as calandering or embossing. The density is determined by a standard method under a load of 0.2 kPa.

Generally, the short fiber-including layer of the fibrous nonwoven according to the invention has an absorbent capacity of at least 3 g/g fibrous nonwoven, preferably at least 4 g/g, particularly preferred of at least 4.8 g/g. The absorbent capacity is measured according to the generally known Syngina test ("Syngina Absorbancy Test") and in the absence of superabsorbent materials.

The present invention furthermore relates to a short fiber which is provided with a finish in an amount of more than 0.035 percent by weight, based on the fiber weight.

According to one embodiment, the short fiber is a man-made cellulose fiber or a synthetic fiber.

According to a preferred embodiment, the short fiber is a viscose fiber which may have a multi-limbed cross-section, such as a three-limbed cross-section.

The short fiber has a length in the range of from 2 to 12 mm, preferably in the range of from 4 to 8 mm such as 5 to 6 mm. Generally, the short fiber has a length-to-weight ratio of 1.0 to 6.0 dtex, preferably 2.0 to 4.0 dtex, for example, about 3.3 dtex.

The finish is present in an amount of more than 0.035 percent by weight, preferably more than 0.05 percent by weight, more preferably in an amount of more than 0.10 percent by weight and most preferably in an amount of more than 0.15 percent by weight, the maximum amount being 1 percent by weight, particularly 0.75 percent by weight such as 0.50 percent by weight.

Suitable finish materials are the finish materials described above in connection with the method according to the invention.

Furthermore, the present invention relates to the use of a short fiber as described above in an airlaid process.

The invention, moreover, relates to an absorbent article comprising a fibrous nonwoven produced according to the method according to the invention and to a fibrous nonwoven as described above, respectively. The absorbent article has an absorbent capacity of at least 3 g/g fibrous nonwoven,

preferably of at least 4 g/g, particularly preferred of at least 4.8 g/g, as measured by the Syngina test.

The absorbent article is, for example, a hygiene article, such as a tampon, a sanitary napkin, a diaper or an incontinence article or a household article, industrial article or medical article.

According to a particularly preferred embodiment, the absorbent article according to the invention is a tampon which comprises a helically winding of a short fiber-including layer according to the invention. The layer comprises 60 to 100 percent by weight of three-limbed short viscose fibers and 0 to 40 percent by weight of short cellulose fibers, based on the total weight of the short fibers. The short cellulose fibers and the short viscose fibers have a length of 4 to 8 mm, preferably of about 6 mm and a length-to-weight ratio of 3 to 4 dtex. Furthermore, the layer comprises 5 to 15 percent by weight of a BICO short binder fiber, based on the weight of short fibers and short binder fibers. The tampon has an absorbent capacity of at least 4 g/g under load, a stiffness of at least 20N and an expansion capacity of at least 150%.

The invention will be described in further detail with reference to the example given below. The example is merely of illustrative nature and should not be interpreted to be limiting in any way.

MEASURING METHOD

DETERMINATION OF THE MOISTURE OF THE FIBERS

1. Moisture-proof containers are weighed with an accuracy of $\pm$ 0.005 g at room temperature and the temperature at which the fiber samples are weighed after oven drying has been performed. The values T_{RT} (tare weight at room temperature) and T_H (tare weight hot) are recorded. Care must be taken that the determination of G_H is performed with open lid.

2. A fiber sample (about 5 g) is introduced into the container. The container is closed by the lid in moisture-proof manner and weighed with an accuracy of $\pm$ 0.005 g. The value G_{RT} (weight at room temperature) is recorded.

3. The lid is removed from the containers and the container and lid are introduced into a hot air oven with a temperature of 105 $\pm$ 3°C.

4. Drying is performed over at least three hours, for example, overnight. During drying the oven must not be opened.

5. While being still in the oven, the containers are closed in moisture-proof manner. The closed container is weighed at the same temperature at which G_H was measured. The value is recorded as G_H (weight hot).

6. Calculation

$$\%\ moisture = \left[1 - \frac{G_H - T_H}{G_{RT} - T_{RT}}\right] x\ 100$$

EXAMPLE

After pretests had been conducted in which the influence of a finish present on the fibers was determined as well as a lesser influence of the fibers' moisture content, fibers according to the specification indicated in Table 1 were produced. The short fiber was a three-limbed rayon fiber (Danofil VY), obtained by dry-cutting using a guillotine process, with a length-to-weight ratio of 3.3 dtex and a length of 5 mm. The finish employed was polyglycol palmitate stearate ester.

The fibers were then used for producing airlaid nonwovens using a Danweb airlaid line with 4 forming heads and a forming width of 600 mm. The airlaid line is suitable for multi-bonding and for producing latex-bonded and thermally bonded products. The bore diameter of the forming heads was 4.5 mm.

The fibers of the samples 1-5 were used in combination with a binder fiber Trevira T255 (PET/PE) with a length-to-weight ratio of 3.0 dtex and a length of 6 mm with a weight ratio of rayon fibers to binder fibers of 93:7. The environmental conditions were 23°C and 73% relative humidity, the target basis weight was 180 to 220 g/m² at a density of 0.04 g/cm³.

In order to determine the maximum throughput of the airlaid machinery, the highest amount of fibers passing through the forming heads without blocking the forming heads is determined. In addition, the basis weight must remain stable at target with a maximum variation of ± 10% from the target value in machine and cross direction. The maximum

capacity is the maximum amount of fibers fed to the forming heads per unit of time measured at the fiber feed metering unit.

The test was successively performed on samples 1 to 5, i.e., the moisture and/or finish values were increased from test to test to avoid contamination of the system by fibers with higher moisture or finish amounts.

In each test the fiber feed was increased up to the point where a fiber accumulation in the forming heads occurred. The last stable setting up to this point is the maximum throughput in the airlaid machinery. The airlaid machinery used two of four forming heads. The results of the tests are summarized in Table 1.

Table 1

Sample no.	Moisture, %	Finish amount, %	Maximum throughput
1	4.1	0.045	120.5
2	8.2	0.031	140.6
3	8.7	0.052	154.0
4	9.1	0.085	170.1
5	9.3	0.16	222.6

Moisture: measured according to the method described herein
Type of finish: polyglycol palmitate stearate ester
Maximum throughput: indicated in kg/h per 2 forming heads

The results are graphically represented in Figures 1 and 2. The results show in particular:

1. An increased finish content as well as an increased moisture content increase the throughput of viscose fibers in the airlaid line.

2. Increasing moisture from 4.1 to 8.7%, with a comparable finish content, increases the throughput from 120.5 to 154.0 kg (+28%) (Fig. 1).

3. Increasing the finish amount from 0.052 to 0.085 and further to 0.16, with a comparable moisture content, increases the throughput from 154.0 to 170.1 kg (+ 10%) and finally to 222.6 kg (+45%) (Fig. 2).

4. The highest throughput was achieved with 9.3% moisture and 0.16% finish. The graphical evaluation given in Figures 1 and 2 suggests that, if moisture and/or finish are further increased, a further increase of the throughput may be expected.

5. The throughputs achieved in these tests exceeded all results obtained so far with synthetic fibers on the airlaid line employed.

6. It is presumed that the throughputs achieved in these tests also exceed the maximum throughputs of 100% cellulose. For the heads with 4.5 mm bore diameter secure data are not yet available. With forming heads having 4.00 mm bores, the maximum values for 100% are about 80 kg/h per forming head, i.e., 160 kg/h per two forming heads.